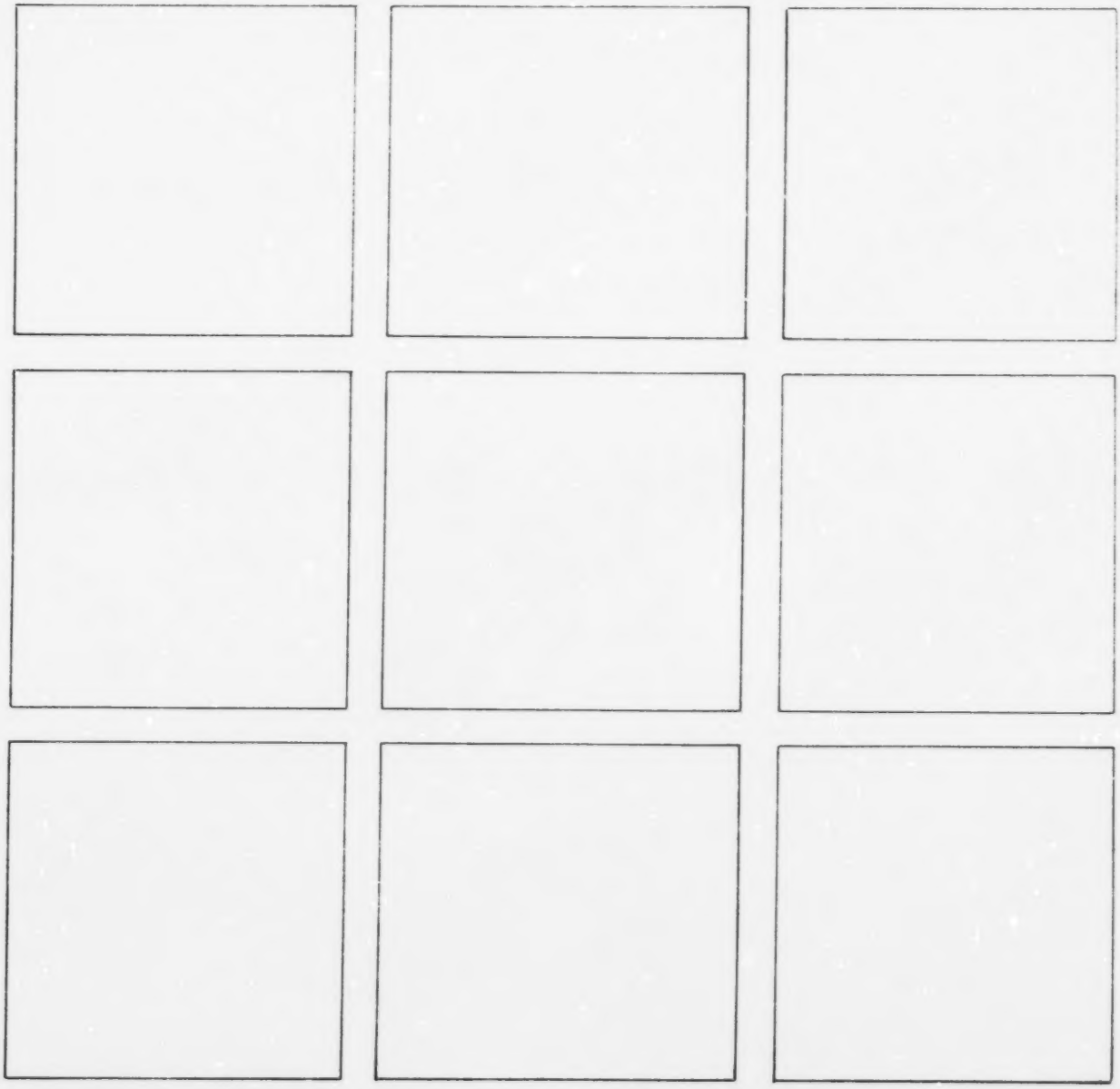
Ontario
Waste Management
Corporation
System
Development
Project

OWMC

Back-
ground
Paper

Waste Reduction



The Proctor & Redfern Group

Consulting Engineers and Planners
75 Eglinton Avenue East
Toronto, Ontario M4P 1H3
Telephone (416) 486-5225 Telex 06-22506

82 07 30

Mr. E.H. Schmidt
Project Director
Ontario Waste Management Corporation
60 Bloor Street West
Suite 707
Toronto, Ontario
M4W 3B8

Dear Sir

Waste Reduction

We are pleased to present the final report of the Background Paper on Waste Reduction.

This report is principally the work of Dr. Robert Laughlin, Assistant Director, Department of Environmental Chemistry, Ontario Research Foundation, a principal subconsultant to Proctor & Redfern. Under his direction, there is now underway a detailed investigation for OWMC examining Waste Reduction Opportunities.

We trust that this background paper is enlightening and assists in an understanding of the real possibilities for waste reduction.

Yours very truly

Proctor & Redfern Limited

W. D. Goodings
Vice-President

WDG:sm
Encl.

BACKGROUND PAPER - WASTE REDUCTION

ONTARIO WASTE MANAGEMENT CORPORATION

There is a hierarchy of approaches to the management of liquid industrial and hazardous waste which . . . are listed below in order of desirability:

1. Waste abatement, non-waste or zero discharge technology.
2. Waste reduction or modification.
3. Waste reuse.
4. Waste refining for recycle.
5. Waste treatment and destruction.
6. Waste disposal

July, 1982

Proctor & Redfern Limited
75 Eglinton Avenue East
Toronto, Ontario M4P 1H3

ONTARIO WASTE MANAGEMENT CORPORATION

BACKGROUND INFORMATION

The Ontario Waste Management Corporation (OWMC) is a provincial crown agency created in 1981 by the Ontario government to establish a liquid industrial waste and hazardous waste management system for the province. One of the first tasks of the Corporation was to examine the possibility of constructing a treatment and disposal facility at South Cayuga in the Regional Municipality of Haldimand-Norfolk. Preliminary hydrogeological studies of the site revealed that it had several short-comings and the Board of Directors of OWMC voted unanimously to reject the site in November 1981.

Following the rejection of the South Cayuga site, OWMC developed a corporate plan which incorporated:

- The need to design and build a waste treatment and disposal system to manage safely liquid industrial waste and hazardous waste not presently receiving adequate treatment and disposal in Ontario.

- The need to assist Ontario industries in identifying additional, practical ways to reduce and/or recycle liquid industrial waste and hazardous waste.

- The need to consult with the public on the nature and scope of the industrial waste problem and how it can be remedied.

Before a treatment and disposal facility is built, detailed proposals must be presented to an independent Hearing Panel appointed by the Ontario Government, and public hearings will be held.

OWMC is not a regulatory agency, nor is it responsible for treating and disposing of domestic or radioactive wastes.

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SUMMARY

1. This report discusses the desirability of waste reduction as a waste management technique particularly as it applies to the development of a waste treatment and disposal system, and identifies potential roles for OWMC to consider in encouraging waste reduction and recovery practices in Ontario.

2. A number of successful waste reduction and recovery practices in several key industries are reviewed along with a brief examination of current waste reduction and recovery activities in Ontario, including the Canadian Waste Materials Exchange Program.

3. A preliminary assessment of recycle/reuse possibilities for various types of wastes is given, using the waste categorization system developed by the University of California at Davis (UCD) to identify the waste streams considered.

1.0 INTRODUCTION

It is generally recognized that there is a hierarchy of approaches to the management of liquid industrial waste and hazardous waste which may be considered. These are listed below in order of desirability:

1. Waste abatement, non-waste or zero discharge technology

2. Waste reduction or modification

3. Waste reuse

4. Waste refining for recycle

5. Waste treatment and destruction

6. Waste disposal

These approaches are not mutually exclusive, and a waste may go through several of the stages outlined. As a hypothetical example, let us consider a solvent waste from a pharmaceutical operation, very slightly contaminated and, therefore, no longer acceptable in this industry. This waste could be reused for metal degreasing. It could then be sent for refining for recycle and the sludge or still bottoms sent for incineration (waste treatment and destruction) where it becomes a fuel to assist in the destruction of other wastes. The ash from the incineration process would then be sent for disposal.

Bill 90, which established the Ontario Waste Management Corporation does not explicitly set out a role for the OWMC in the reduction and reuse of waste materials. In our view, the objectives of OWMC are sufficiently broad to encompass reuse and reduction as one method of "treatment and disposal of wastes".

A major study has been recommended and is planned for the summer and fall of 1982 which will have as its broad objectives:

1. An assessment of the opportunities for reducing, reusing or recycling industrial wastes in the Province of Ontario.

2. A determination of what roles OWMC might assume to maximize the opportunities in Ontario for waste reduction, reuse and recycle, and to ensure that those opportunities are realized.

This paper has been written based on general background information and is organized as follows:

A section entitled "Background" which discusses:

- The desirability of waste reduction as a waste management technique

- The importance of waste reduction to the development of a waste treatment and disposal system

A "Waste Reduction Opportunities Study Outline" section which summarizes available information including:

- A technical review

- An examination of waste reduction and recovery activities in Ontario

- Potential roles for OWMC to consider in encouraging waste reduction and recovery in Ontario

and

A final section entitled "Initial Assessment of the Potential for Waste Reduction in Various Waste Types."

2.0 BACKGROUND

2.1 The Desirability of Waste Reduction as a Waste Management Technique

There are few who would argue that the reduction or elimination of waste is not a more desirable technique than treatment or ultimate disposal for the management of that waste. It is somewhat analagous to preventive medicine being much more desirable than major surgery or, again, in extreme cases, "ultimate disposal." Table 1 on page 27 reproduces "The Ten Commandments of Resource Recovery." This is a humorous look at the limits of practical resource recovery but it is based on some very realistic concepts.

Even within the general area of waste reduction/recycle, there is a hierarchy of approaches to be considered. These we have termed:

- Waste Abatement
- Waste Reduction
- Waste Reuse
- Waste Recycle

These terms are defined in Table 2 on page 27 and brief examples are given to illustrate the definition. While all of these approaches to waste management can be considered desirable, Abatement is preferred to Reduction, which is preferred to Reuse, etc.

Waste abatement, the application of low waste or zero waste producing technologies, eliminates or dramatically reduces the production of waste. This has to be considered as the ultimate solution to the problem; to not create the problem in the first place.

Waste reduction is considered as the second most desirable approach because it involves simple inexpensive in-plant housekeeping practices to ensure: (a) that the quantities of waste are minimized, and (b) that a simple possibly reusable or recyclable stream is not turned into a non-reusable, non-treatable waste stream, by mixing together all of the plant's waste streams in one common sewer or disposal tank.

If the substitution of a zero waste technology is not practical and good housekeeping practices have been implemented, the third most desirable option for that waste stream is direct reuse. Reuse of the waste may be by the plant that produced it, or it may be necessary to find a user in a different plant, possibly in an entirely different industry sector. Direct reuse of a waste stream as a substitute raw material, without any processing or upgrading, is preferred over waste recycle or reclamation on two counts: (a) any processing incurs cost in both dollars, and, in many instances, energy; and (b) processing is only undertaken to separate the desirable component from any undesirable admixed components. This means that recycling processes generally produce a residual which must be properly treated and ultimately disposed.

While comparing waste recycling or reclamation unfavourably with waste reuse, it is still a very desirable approach when compared to treatment, destruction and disposal. Many recycling operations, such as solvent recovery or waste oil re-refining, recover a very large proportion of the waste fed to the process, leaving a very small residual for treatment or disposal. Some recycling technologies, such as proposed methods for the recovery of precious metal values from sewage sludge incinerator ash, will recover only a very small, high-valued proportion of the waste, leaving the volume for treatment and disposal virtually unchanged.

Some people view the encouragement of waste abatement, reduction, reuse, recycle practices and the establishment of proper waste treatment and disposal facilities as being mutually exclusive. This, in our view, is not the case. Both are necessary and desirable in an integrated waste management plan. The hierarchial list of waste management approaches -

1. Waste abatement

2. Waste reduction

3. Waste reuse

4. Waste recycle

5. Waste treatment and destruction

6. Waste disposal

is a continuum becoming less desirable from 1 to 6. There are many factors which influence what waste management approach is most appropriate for any particular industrial waste problem. Most of those factors can be expressed in economic terms, and a responsible industrialist will select the lowest cost, legally acceptable approach. Statements such as this raise the ire of some environmentalists who sometimes question that economics will be the major determinant as to whether wastes will be recycled or disposed. There are also environmental reasons why we should not try to recycle all waste streams. The energy requirement to return some waste materials to a form in which they can be used may be so great that the very production of energy with its attendant environmental problems may result in greater environmental damage than simply disposing of the industrial waste in a properly designed waste treatment or disposal facility.

The uncertainty of what proportion of the waste stream is potentially recoverable is discussed in a recent article in Environment. (*1) Three different estimates for the United States are quoted. EPA cites a 1976 study by Arthur D. Little which estimates "only 3% of the 350 million metric tonnes of industrial waste generated that year were potentially marketable or reusable;" (*2) the National Solid Waste Management Association contends that "recovery techniques have the potential to reduce the hazardous waste load by as much as 20%." (*3) But, by far the

most optimistic forecast comes from Dr. Paul Palmer of Zero Waste Systems Inc., a California-based commercial chemical recycling company, who claims that "80% of the chemical waste now buried at landfills or processed through other disposal methods could be recycled." (*4)

In Canada, the Canadian Waste Materials Exchange has matched waste generators with potential users for 15% of the waste streams listed in its bulletins. (*5)

A problem with this data is that the bases of the three American estimates are all different and none can be regarded as a definitive estimate for recovery potential. Similarly, the Canadian Waste Materials Exchange information represents percentages of waste which were listed voluntarily. None of these findings present conclusive data.

The choice of waste management approaches will change with time and the existing economic situation. Today there are three major economic trends which are all working positively to encourage industry to consider moving up the hierarchy of waste management approaches toward waste abatement. These are:

- The cost of some raw materials is rapidly escalating, and in fact, the continuing availability of at least some of those resources is quite uncertain.

- The cost of energy to process these raw materials into usable commodities is increasing at an even greater rate.

- The cost of proper waste treatment and disposal is for the most part also growing at a rate higher than general inflation.

These basic underlying economic motivators, in our view, could stimulate the following:

- Industry will examine primary processes to determine whether basic changes can be made to eliminate production of the waste.

- Research and Development programmes on a new non-waste or low waste technologies will be initiated.

- In-plant waste handling practices will be examined to ensure that the quantity of waste and the contamination of potentially recyclable waste are minimized.

- More serious consideration will be given to using waste streams as raw materials. Traditional raw material specifications will be re-examined in the light of high costs to meet those specifications.

- Recycling and recovery businesses will be established as the market for recovered products grows.

Governments can influence the trend towards abatement, reduction, reuse and recycle through tax incentives and strong legislation to ensure that, if wastes are not reused or recycled, they are directed toward proper treatment, destruction and disposal.

Potential roles for OWMC to influence the trend towards abatement, reduction, reuse and recycle are discussed in a latter section of this paper. Many of these potential roles fall into the category of providing effective information transfer to ensure that no one is ignorant of available waste reduction technology. Other potential roles in the operation of recycling faciilities are also considered.

2.2 The Importance Of Waste Reduction To Development Of Waste Treatment

A thorough understanding of trends in waste abatement, reduction, reuse and recycle is imperative for the proper design of a waste treatment and disposal system, even if the operator of that system has no direct involvement in waste reclamation. The system designer must realize that waste reduction or recovery implementation results in drastic changes in both the quantity and the nature of waste for disposal.

Some European operators of central waste treatment and disposal facilities advised (7), the OWMC study team that they have found that they over-estimated the quantity of waste requiring treatment. Much of that over-estimating is attributed to unanticipated reduction and recovery implementation with the resultant reduction of the total volume of the waste strea.

Of equal concern is the change in the nature of waste streams as waste reduction and reclamation is practiced. Solvent recovery is an example. The original waste stream is highly fluid and energy rich. After a recovery operation, a highly viscous, sometimes solid, sometimes very high ash residue is produced. Materials handling and treatment facilities required for this residue are very different from those required for the original solvent waste.

Aqueous acid and alkaline wastes are often neutralized in-house by industry to avoid the high cost of transporting large amounts of water to a waste treatment and disposal facility. Neutralization results in two streams; an aqueous stream which is discharged to the sewer, and a residual sludge which must go to a proper treatment and disposal facility. If that facility has designed its equipment only to handle large volume acqueous waste streams, it may have difficulties in coping with several 45-gallon drums of filtered sludge. Advice offered by Rechem, a British waste management company, is "keep your plant flexible enough that it can respond to changes which will occur in both quantity and nature of the wastes to be treated, due to resource-recovery activities within industry."(*6)

Resource recovery and waste recycle must also be considered as possible direct elements in the planning of a waste treatment and disposal system. A number of European waste treatment and disposal facilities are also involved in waste recycling. Solvents and waste oils are the most common materials recovered. An interesting process is being operated by SARP Industries in France (*7). Waste ammoniacal copper solutions from the printed circuit board industry are being treated for the recovery of

ammonia and a copper oxide product. The result of this treatment is two marketable products plus a waste water stream which can be discharged to a sewer. This is a good example of the role which a central waste treatment facility can play in resource recovery. Individual printed circuit board manufacturers would be unable to justify a recovery system based on their individual waste volumes. SARP Industries, by collecting from many manufacturers, whose wastes are all very similar, assembles sufficient volume to justify a recovery system. This is an excellent example of total resource recovery. There is no unwanted residue produced from the process. Unfortunately, not all resource recovery processes are as ideal.

To summarize, it is essential that the planner and developer of a waste treatment and disposal system thoroughly understand the trends in waste reduction which are occurring in industry so that they may design their system for wastes which will actually arrive. Further and more difficult to gauge, they should recognize that there will be changes which cannot be predicted at this time, and design flexibility into the system. Finally, the waste treatment system may include some processes for resource recovery. These must be carefully chosen; a planner must recognize that industries with a large enough stream, say of solvent waste, may consider in-plant recovery, and that a number of specialized recovery firms do exist and may be created in the future, to compete for the waste. Resource recovery facilities within the waste treatment and disposal system must be chosen to serve a market not well served today, and should probably concentrate on wastes from small generators which they can bulk to create an economically viable volume for recovery.

3.0 WASTE REDUCTION OPPORTUNITIES STUDY OUTLINE

3.1 Introduction

As was stated earlier, a study is being planned to discover practical waste reduction opportunities. The study will address three major areas:

- Technical review of opportunities for abatement, reduction, reuse and recycle.
- An examination of waste reduction and recovery activities in Ontario.
- An examination of potential roles to be considered by OWMC to encourage waste reduction and recovery in Ontario.

3.2 Technical Review

Prior to undertaking the study, a preliminary discussion of these three areas follows.

Waste Abatement

In reference to Table 2 on page 27, we have defined waste abatement as:

"The substitution of a new low-waste primary industrial process for an old process to eliminate or drastically rduce the quantity of waste produced".

Because this approach to the elimination or reduction of waste is achieved within the primary industrial process, it is difficult to discuss any universally applicable technologies. In order to understand what can be achieved or what is being achieved, a thorough examination of each industry sector, and even each process within an industry sector, is required. Two examples of industrial waste abatement technologies are given below to illustrate what is meant by this approach.

Industrial Paint Application

A major category of difficult-to-handle industrial waste is the sludge from the industrial application of paints and coatings. These are often solvent-based oil and acrylic paints, which are applied to objects in a spraybooth, with a sheet of water running down behind the object being painted to wash down the paint overspray to a sump which is emptied periodically. The resultant paint sludges can be up to 90% water but have the consistency of solidified putty.

In a new development in the paint industry, pigment and polymer are applied as a dry powder using electrostatic charging of the target object to be painted, and charging the paint powder with the opposite charge. A very high proportion of the paint impacts the object to be coated. Any overspray, since it is dry, can be swept up and returned to the spray gun. The coated product is then baked in a curing oven. This development totally eliminates the production of troublesome paint sludges, and it enjoys virtually 100% utilization of pigment and polymer as part of the painted product.

Iron and Steel Manufacturing

For many years, the iron and steel industry has used sulphuric acid to "pickle" (or clean) the surface of their steel prior to such operations as galvanizing, etc. This has given rise to a waste stream containing iron sulphate and residual sulphuric acid which was generally referred to as spent pickle liquor. The substitution of hydrochloric acid as the pickling acid allows the acid to be recycled since the pickling action gives rise to iron chloride and spent hydrochloric acid. The iron chloride in this waste liquor is readily broken down by heat to iron oxide and hydrochloride gas which is absorbed to form hydrochloric acid and returned to the pickling tanks. So, while this is also an example of a recovery or recycling process, the key to its success is really in the substitution of hydrochloric acid for sulphuric acid in the primary process. A similar decomposition of iron sulphate is not possible.

3.2.2 Waste Reduction

Waste reduction has been defined as:

"The reduction of the quantity of waste through good housekeeping practices or by the application of concentration technologies. Also, the reduction of the degree of hazard of wastes through simple in-plant treatment."

This approach is quite industry-specific and process-specific, but some common themes can be discussed. Good housekeeping practices referred to in the definition mean that there are specific practices within the primary industrial processes to ensure that no waste more than is absolutely necessary is produced, and that there is an industry-wide practice to ensure that potentially reusable or recoverable wastes are not rendered useless by being mixed together or mixed with non-recoverable wastes. Many older plants have common in-plant drainage systems that direct all wastes to a common collection tank. This practice, particularly if the plant produces a complex mixture of wastes, unfortunately will ensure that recovery is either not possible or very expensive, and, if recovery is not possible, might result in much higher treatment and disposal costs. Changes in housekeeping practice can often be instituted at a very minimal cost and therefore is a very attractive initial step towards reduction of waste.

Reduction of waste volume or changes in its nature through simple in-plant treatment, has a group of common applicable unit operations. These operations are mainly techniques for the separation of waste components from an aqueous stream, and include:

Ultrafiltration,	Centrifugation
Reverse Osmosis	Neutralization
Evaporation	Settling
Filtration	Distillation
Electrodialysis	

Good Housekeeping

Consider a hypothetical example of an industry whose processes use both a chlorinated and a non-chlorinated solvent. If wastes from both processes are kept separate, the waste solvents can be readily recovered. If both solvent wastes are discharged to a common waste tank, solvent recovery becomes much more difficult, if not impossible. This plant, therefore, has a volume of waste for treatment and disposal, all of which is regarded as a chlorinated organic waste. Since the cost of disposal of chlorinated organic waste is much higher than for a non-chlorinated waste, the industry loses an opportunity to save money both on solvent acquisiton and waste treatment.

Waste Reduction

Figures 1 on Page 28 shows electroplating flow sheets before and after the introduction of waste reduction through the use of electrodialysis. In the "before" case, rinse water containing the metal salts used for plating was treated using an ion-exchange resin. Regeneration of the resin resulted in a stream which required treatment prior to discharge. The result of this treatment was the production of a metal hydroxide sludge for disposal. The introduction of electrodialysis, which is a process that concentrates metal salts in dilute solutions, results in about a 90% reduction in the quantity of sludge produced; and by recycling the metal salt concentrate, also significantly reduces the raw material requirement of the plating process.

Waste Reuse

This option has been defined as follows:

"The direct reuse as a raw material of a waste stream as is, or with very minor modification."

This is also a very plant-specific operation, and many times the internal reuse of wastes or by-products has been practised for so long that it is not considered waste reuse, but part of the primary process. As an example, at an integrated steel complex, coke for use in the blast furnace is produced from coal by a gasification process. The by-product gas is used as a fuel in other areas of the steel mill. In most thermoplastic fabricators' operations, any trim (known as "home scrap") is returned to be remelted and reprocessed. Many of the giants of the German chemical industry today, such as Bayer, BASF and Hoechst, began as waste reusers. The growing practice of coal or town gas production in the 19th Century resulted in the simultaneous co-production of tar, ammonia, benzol, phenolics, etc. The innovative use of this waste as a raw material for dyestuffs, pharmaceuticals and the production of other chemicals resulted in the establishment of these three large corporations.

To promote and implement the use of a waste stream in plants not associated with the producer of the waste requires more effort than an internal plant situation. The barriers or difficulties include the economics of haul, ownership and legal considerations and assurances of quality. In our view, an important barrier to a more widespread use of waste streams is simply that potential users do not know that another party has this useful "waste". This communication problem has given rise to establishing central information clearing houses or agencies called Waste Exchanges.

In Canada, the Canadian Waste Materials Exchange publishes a bulletin six times per year in which generators list waste streams which are available, and potential users can list waste streams which they are seeking as substitute raw materials. The bulletin is sent to several thousand industrial participants. Any potential users or potential suppliers of the listed wastes are put into contact with each other and they may negotiate a satisfactory arrangement. The Canadian Exchange is a "passive" exchange, dealing only in information and acting more or less as a "marriage broker." Other Waste Exchanges may actually participate in the negotiations and may take legal possesion of the waste stream prior to reselling to a user. (*8)

- Solvents used in the electronics industry for contact cleaning or circuit board cleaning are only very slightly contaminated before they are considered to be unsuitable for further use. These solvents can be readily used directly by the paint industry with no intermediate purification step.

- By-product phenol from petroleum refining operations at about 96-98% purity can be reused in the production of phenolic thermoset plastic resins.

- Fly ash from electrical power generation is used as raw material in the production of lightweight aggregate and lightweight structural concrete.

Waste Recycle and Recovery

Waste recycle and recovery has been defined as:

"The reclamation of value from waste streams through the application of reprocessing technologies such as distillation, etc."

Waste abatement, reduction and reuse are basically industry-specific activities. Recycling or recovery operations can be in-house industry operations, but, generally this is regarded more as a waste treatment facility activity, taking waste from several industry sectors, and reprocessing them for reuse. This is done either on a "toll" basis, i.e. the waste from a particular company is collected and reprocessed and returned to that company for a fee, or a reprocessor buys the waste, reprocesses it and markets the recovered material.

The two most widely applied recycling operations are solvent recovery and waste oil rerefining. These are briefly described below:

- Solvent Recovery

The variety of solvents which can be reprocessed in recovery operations include: (*9)

1. Halogenated hydrocarbons such as methylene chloride and trichloroethylene used in degreasing, metal cleaning, and dry cleaning.

2. Aliphatic and aromatic hydrocarbons, alcohols, acetone, hexane, and butyl acetate used in various chemical process industries such as paint manufacturing, printing operations and industrial paint uses.

3. Numerous special solvents such as freon and phenol.

If a simple mixture of solvent and contaminant with large differences in volatilities is the waste to be treated, or if the purity of the recovered solvent does not have to be too high, a simple distillation process can be used. Waste is fed to a simple pot still where the solvent is vapourized and routed to a condensing unit and the contaminants which remain in the "still bottom" as sludge are drawn off for subsequent disposal.

If a complex mixture of solvents must be separated or if the purity requirements of the recovered solvent are very high, an additional step is required after the evaporation of the solvent vapours. In this case, a "fractionation column" is utilized. When operated in a continuous mode, this fractional distillation process will produce a high-purity single solvent product. Operated in a batch mode, fractional distillation can result in the production of several solvent products, the most volatile solvent being produced first followed by the next most volatile, and so forth.

A typical solvent recovery operation is depicted in Figure 2, on page 29, which illustrates the principal equipment components used as well as an approximate mass balance.

- Oil Re-refining

The traditional process used in waste oil re-refining has been the acid-clay process as illustrated in Figure 3 on page 30 (*10).

There are several problems associated with the acid-clay re-refining process as applied to today's waste oils; the additives and detergents in today's oil are causing increased acid and chemical usage; only about 75% recovery of usable product is possible; the acid tar and spent clay residuals are corrosive and contain significant quantities of heavy metals, primarily lead; the acid tends to render the heavy metals leachable, and disposal must be in a secure manner.

New processes have been developed to address these problems. One such process is the Phillips Re-refined Oil Process, dubbed PROP by its developers, the Phillips Petroleum Company., The Company claims several advantages for their process over the conventional acid-clay process, namely:

- Recoveries of 90% can be achieved.

- The by-product filter cake can be safely disposed of is appropriately designed and operated landfills.

- Following pretreatment, the aqueous phase by-products may be discharged to a municipal sewer system for subsequent treatment at a conventional municipally owned sewage treatment plant.

- The metals content of the re-refined oil is less than 10 mg/L. (*11)

Shell Canada has recently installed a PROP unit in Toronto and is actively seeking waste oil feedstocks for this unit.

3.3 An Examination of Waste Reduction and Recovery Activities in Ontario

This Section is not a complete inventory of all activities in Ontario. However, an attempt is made to give a few examples of waste reduction and recovery activities which are known to be pursued in the province. Part of the subsequent major study is to determine what activities are

being undertaken by industry in Ontario, and, at the same time, what reduction and recovery opportunities are not being pursued, and why they are not.

At least one of the major steel producers in Ontario has switched their pickling lines to hydrochloric to avoid the production of waste pickle liquor. Several paint applicators in the province have changed to water-based paints to reduce or eliminate their paint sludge disposal problems.

Many Ontario companies are re-examining their waste distribution systems within their plants to try to separate concentrated waste streams before they become diluted by other rinsewater streams. Other improved waste housekeeping practices are being pursued.

Waste reduction is being actively undertaken, particularly in the surface finishing industry within the province. The metal finishing industry in Ontario has been undertaking in-house cyanide destruction for many years to render their waste streams less hazardous. Many companies are now considering or have installed ion exchange, electrodialysis or reverse osmosis for metals recovery.

In-plant reuse of waste is undertaken by the plastics fabricators of Ontario. Several of the paint manufacturers are actively seeking slightly contaminated solvents from other industries which they can utilize in paint formulations, or if they are slightly more contaminated, for wash-up of mixing equipment. Shredded rubber tires are being used to produce underpadding for carpet, and as bulking agents in the composting of sewage sludge.

There are several examples of in-plant recycling, one of which is a major Toronto newspaper's installation of an ink recycling system. (*12) Oil refineries which use monoethanolamine or diethanolamine for scrubbing of gases have recycling facilities in-house for these solvents. Several in-plant solvent recovery facilities exist within Ontario industries.

There is quite a large recycling industry within the Province of Ontario. The traditional recycling industry or "scrap dealers" dealt mainly with paper and ferrous and non-ferrous metals and also with old automobiles. Information on this industry is available from the Canadian Association of Recycling Industries (CARI) in Toronto. We know of at least seven oil refiners within the province and at least five solvent recovery firms, and there may be others. One company recycles spent pickle liquors as long as those liquors are not highly contaminated with heavy metals. Iron is added to the spent liquors to react with any remaining acid. The iron salts are then crystallized and sold as chemicals for use in sewage treatment facilities. At least two companies are active in the drum reclaiming business in Ontario, and two other companies collect food wastes and recycle these as animal feed.

Other activities in Ontario, designed to encourage the reduction and recovery of wastes, are the operation of the Canadian Waste Materials Exchange by Ontario Research Foundation, and the soon-to-be published "how-to" handbook, Profit from Pollution Prevention: A Guide to Industrial Waste Reduction and Recycling which has been written by Moni Campbell and Bill Glen (*13) of Pollution Probe.

3.4 Potential Roles to be Considered by OWMC to Encourage Waste Reduction and Recovery in Ontario

Waste abatement techniques may range from minor process modification to complete replacement of a process with new non-waste technology. The essence of the waste abatement approach is to change the primary industrial process so that waste is no longer produced, or less of it is produced, or that the waste that is produced is less hazardous.

Waste Abatement

This is primarily an in-house responsibility for industry in Ontario. Some specific roles which might be considered for OWMC might include:

- Acting as a public information clearing house for techniques that are available for a given industry to reduce waste generation. Further conferences on this topic could be arranged to publicize the effort and to gather and disseminate the most current information.

- Acting as an information service for the engineering and waste management firms that could be employed to provide industry with specific technical and operation advice on waste abatement.

- Facilitating loans or financial information about opportunities for investment in waste abatement processes.

- Examining what economic incentives are required to make non-waste or low waste producing industrial technologies attractive.

- Referring industries interested in waste abatement to operational and/or design experts.

- Sponsoring and encouraging research and development in this area.

Waste Reduction or Modification

Waste reduction or modification covers a range of activities undertaken by industry in-house to reduce or modify wastes resulting from their primary processes. These activities may range from simple changes in "housekeeping" practice to installation of relatively sophisticated treatment systems. This again is primarily an industrial responsibility. However, it is anticipated that a more active role could be considered by OWMC in this area than in waste abatement.

Specific potential OWMC roles might include the following:

- The 6 roles noted under "Waste Abatement" can be considered.

- Training OWMC staff to advise on improved housekeeping practices when visiting plants to determine their waste disposal needs.

- Providing mobile equipment to undertake in-house reduction of waste, e.g. reverse osmosis, ultrafiltration, etc. This could be offered as a service to all industries, particularly those who could not justify the capital investment in equipment.

Waste Reuse

Waste reuse is the utilization of a waste stream directly as a substitute for virgin raw materials, without any major modification being made to that waste stream. One of the greatest barriers in our view to widespread reuse of waste streams is a lack of knowledge of the existence of the streams, their composition, their availability, reliability, etc. Reuse within a company is the simplest means of reusing waste. However, if only in-house opportunities are explored, reuse of a particular waste stream could be severely or totally curtailed.

A fairly significant role might be considered by OWMC in this area in conjunction with others already active within Ontario.

The OWMC might consider the following roles:

- Working closely with the Canadian Waste Materials Exchange, providing referrals, and help to locate new users of the service, which, in its turn, will aid in finding users for waste streams. OWMC could advise the Canadian Waste Materials Exchange on how it might improve its service to be more responsive to OWMC needs.

- In an advisory capacity, aiding those who are involved in or developing an "active" waste exchange business. This might include technical and financial information or actual direct technical support during the organization, start-up and initial operation of such a business.

- Operating an active waste exchange. Of particular usefulness might be to consider operating a bulking facility for institutional and laboratory wastes. There is a definite need for this type of activity within Ontario.

- Sponsoring conferences which highlight presentations by industrial users of industrial wastes as substitute raw materials.

- Acting as a clearing house of technical information on reuse opportunities.

- Examining the economics of reuse, and advise the Ontario and Federal governments on what tax incentives should be put in place to encourage reuse.

- To examine the regulatory framework to determine whether it encourages waste reuse, and recommended to the legislators and regulators changes where appropriate.

Waste Refining for Recycle

There are many businesses involved in some refining of waste streams to upgrade them to a point where they can be reused. Their activities might be considered as treatment processes since they normally produce some form of residue which requires ultimate disposal. However, a high proportion of these waste streams are often returned to a productive industrial use.

Potential OWMC roles which might be considered are the following:

- Providing a referral service on refining facilities available to industries with suitable wastes.

- Facilitating or providing financing for the development of waste recycling facilities.

- Providing information as to what tax incentives may exist or should be considered to encourage the use of recycled materials.

- Considering establishing facilities for refining materials not currently covered by existing private recyclers.

- Considering how such facilities would fit into the overall OWMC system network.

- Selecting, where possible, treatment techniques for OWMC facilities, opting for those which result in a recyclable product.

- Considering what regulatory incentives are required and could be implemented to encourage the reuse of recycled materials.

The OWMC mandate suggests that it should take a leadership role in liquid industrial waste and hazardous waste management in Ontario. Implementation of its waste management policies will probably be through direct action or through established or new private sector ventures. Throughout, careful consideration should be given as to how OWMC will relate to the private sector in encouraging waste reduction in Ontario.

4.0 INITIAL ASSESSMENT OF THE POTENTIAL FOR WASTE REDUCTION IN VARIOUS WASTE CATEGORY TYPES

The waste categorization system being used in other reports to OWMC Waste Quantities Study by waste categories, and Generic Process Technologies Study applicable to those waste quantities) is a system developed by the University of California at Davis (UCD). For consistency with these other reports a table is included as Appendix "A" to this paper, in which we list UCD waste categories and annotate for each one our opinions on "Reuse/Recycle Opportunities", and "Probable Quantity Trends" affecting the design of treatment and disposal facilities. The table was not constructed on a rigorous, mathematical basis, and should be regarded as an initial assessment based on informed opinion.

In this section we present a more general discussion of potential for waste reduction by broad category types.

After four years of operation, the Canadian Waste Materials Exchange has achieved an overall success rate of 15 wastes transferred per 100 wastes listed. The rate of waste transferred is quite variable when analyzed on a waste category basis.

	No. of Wastes Transferred per 100 Wastes Listed
Organic Chemicals & Solvents	28
Oils, Fats & Waxes	24
Acids	13
Alkali	12
Other Inorganic Chemicals	8
Metals & Metal Containing Sludges	12
Plastics	19
Textiles	12
Paper and Wood	15
Miscellaneous	14

This pattern of experience by the Canadian Waste Materials Exchange is consistent with the experience of other waste exchanges and reflects trends observed by European operators of waste treatment and disposal facilities.

In our view, all wastes which contain petroleum-based products are the prime candidates for waste abatement, reduction, reuse and recycle. Metal-containing waste streams are not so popular for reuse or recycle because the economics of metal recovery ate present are either marginal or slightly negative. There is, however, a very rapid trend toward primary process modification at the application of in-plant reduction technologies to minimize the production of metal-contaminated waste streams.

There is some movement toward acid recovery, as witnessed by the use of a process developed by ECOTEC, a Toronto-based company. There is a definitive move, certainly commented upon by European treatment plant operators, to reduce the volume of acid or alkaline wastes by neutralizing the wastes in-plant and shipping the dewatered sludge product, rather than the total aqueous acid or alkaline waste streams.

All liquid organic streams are prime candidates for recovery. Some of the recycling processes used will result in the production of a solid or semi-solid residue for disposal. Liquid acid and alkaline streams are being recovered or neutralized. Metals are being reduced by process modification. The major trend is to reduce the volume of wastes requiring treatment and disposal to more complex and concentrated form.

TABLE 1

10 Commandments of Resource Recovery

1 Thou shalt have the waste at your disposal

2 Thou shalt not expect to find a gold mine in your waste

3 Thou shalt not believe in total resource recovery

4 Thou shalt not produce anything from refuse, which no one wants to buy

5 Thou shalt not forget the cost of resource recovery

6 Thou shalt dispose the residues

7 Thou shalt activate the energy in waste with the least possible losses

8 Thou shalt have different recovery systems for different types of waste

9 Thou shalt have different recovery systems for different countries

10 Thou shalt take care of your environment when making resources

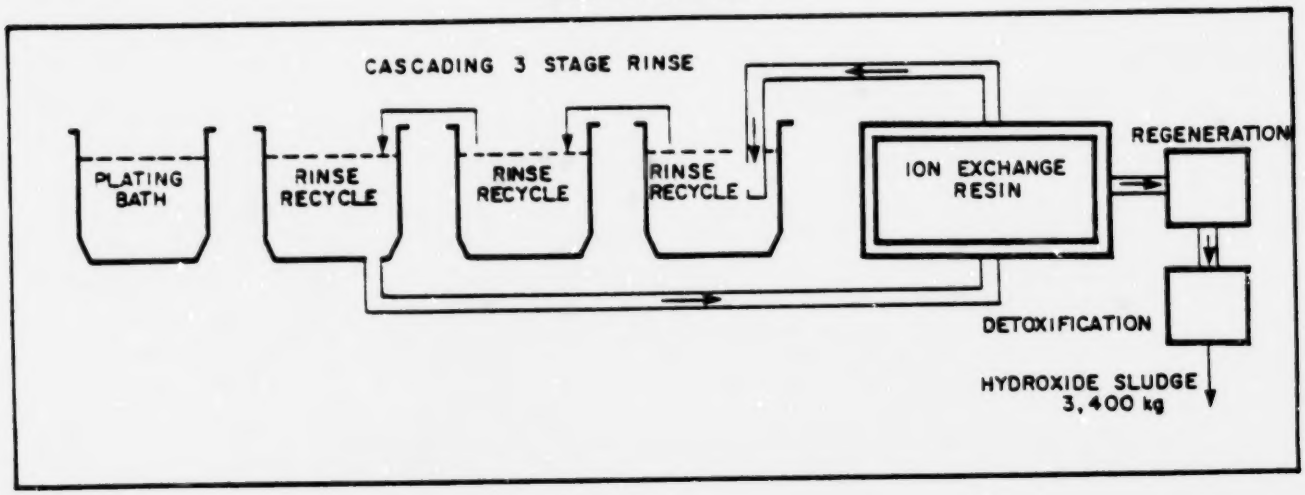
MVU

Source: Mannesmann Veba Umwelttechnik Gmbh, West Germany, 1982.

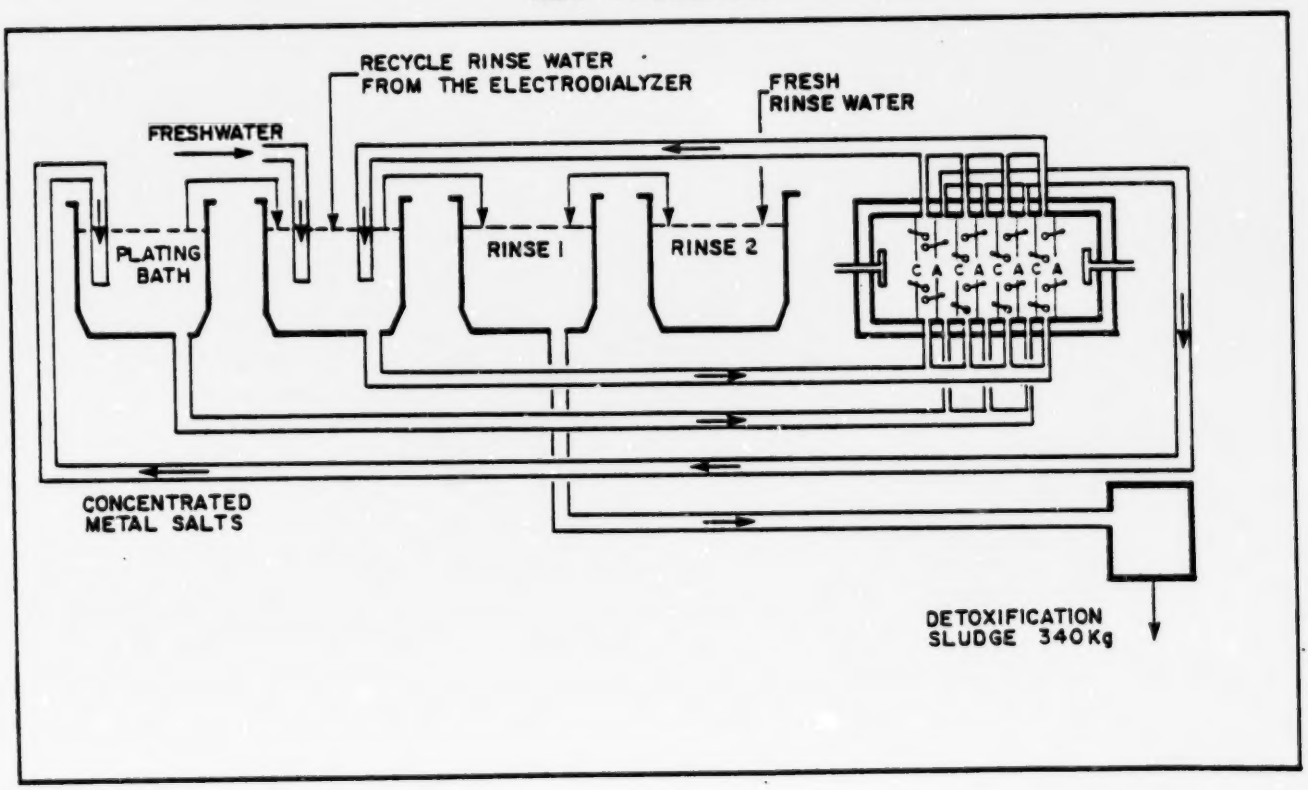
TABLE 2
DEFINITION OF TERMS

Definition	Examples
1. **Waste Abatement:**	
Substitution of a new low-waste primary industrial process for an old process to eliminate or drastically reduce the quantity of waste produced.	- Replacement of cyanide in electroplating solutions. - Replacement of solvent-based paints by water-based ones.
2. **Waste Reduction:**	
The reduction of the quantity of waste through good housekeeping practices or by the application of concentration technologies. Also the reduction in the degree of hazard of waste through simple in-plant treatment.	- Separation of waste streams to permit recovery. - Recovery of metals from electrodialysis - Neutralization of wastes and precipitation of smaller volume sludges.
3. **Waste Reuse:**	
The direct reuse of a waste stream, as is, or with a very minor modification.	- Use of solvents from electronics industry in paints manufacture. - Use of refinery caustic in pulping of wood. - Use of paint sludges as sealants.
4. **Waste Recycle:**	
The reclamation of value from waste streams through the application of reprocessing technologies such as distillation, etc.	- Oil rerefining. - Solvent distillation. - Secondary aluminum smelting. - Iron salts from pickle liquor.

OLD PROCEDURE



NEW PROCEDURE



SOURCE : No. 14, Les techniques propres dans l'industrie, FRENCH MINISTRY OF ENVIRONMENT, 1981.

FIGURE 1 - ELECTROPLATING

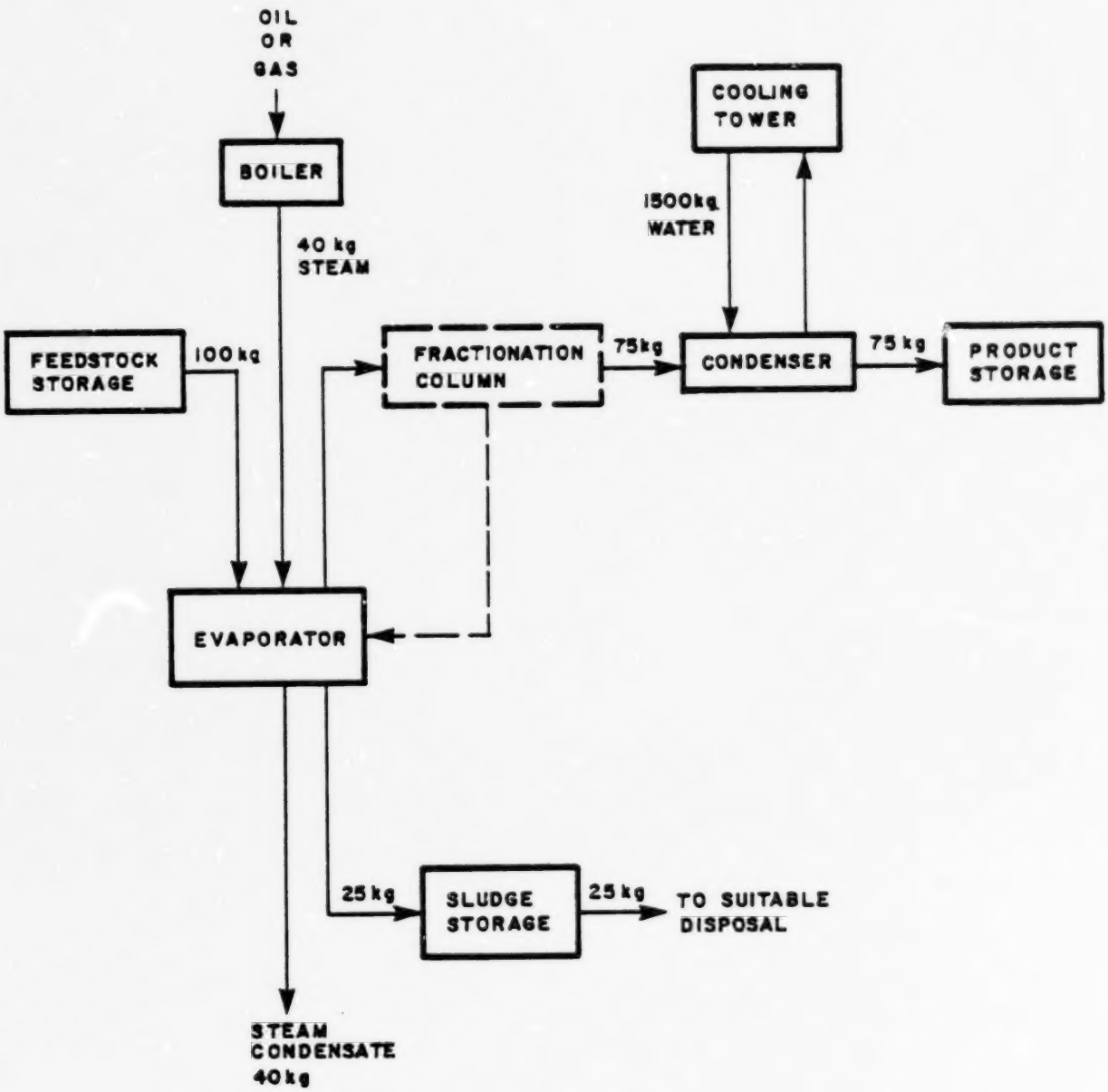


FIGURE 2 - TYPICAL SOLVENT RECOVERY SYSTEM AND MASS BALANCE DIAGRAM

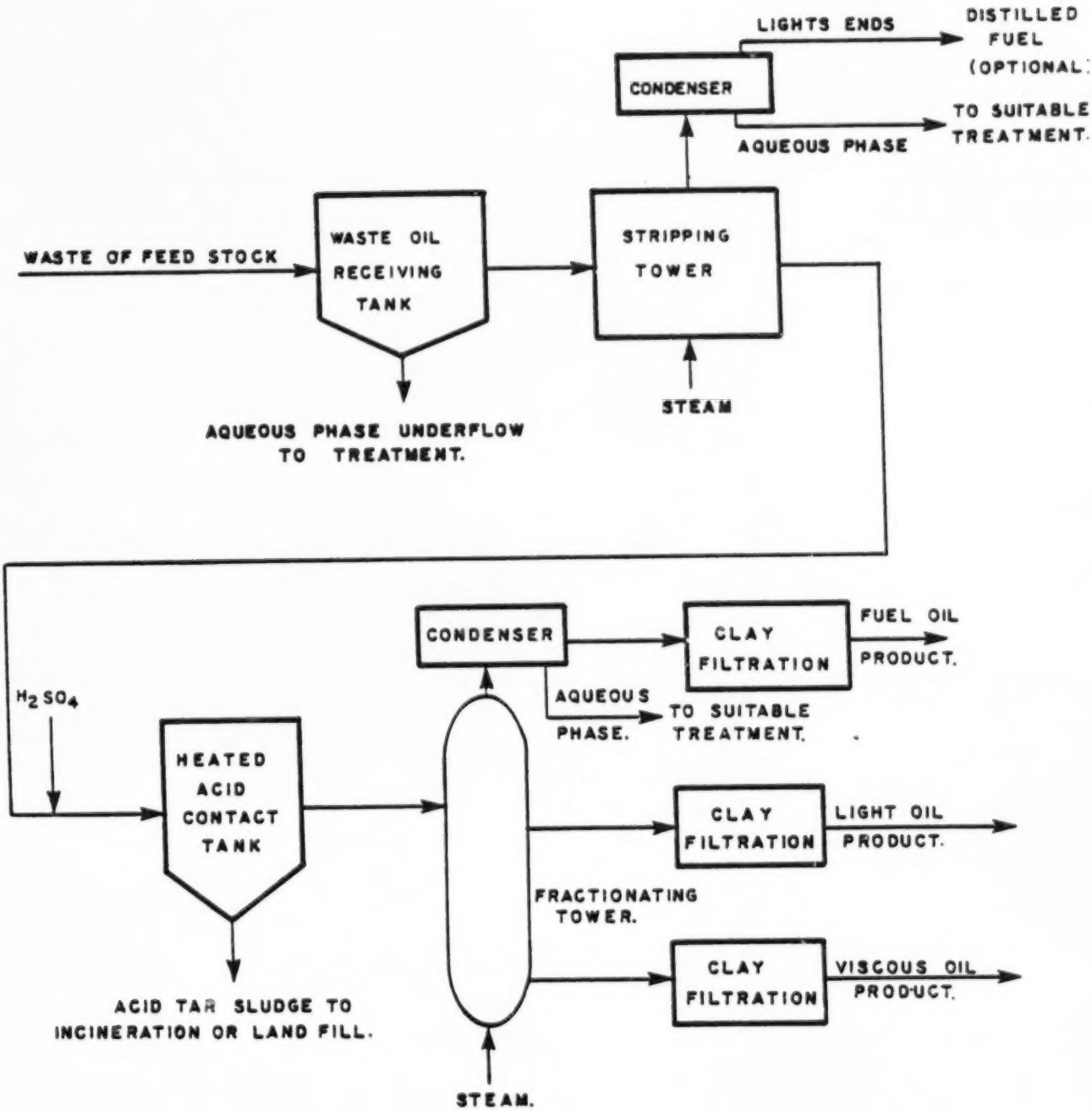


FIGURE 3 — PROCESS SCHEMATIC FOR CONVENTIONAL ACID-CLAY WASTE OIL REFINING PROCESS.

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APPENDIX A

INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

Inorganics	Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
(11) Acidic Solutions		
(111) Acidic solutions with heavy metals.	Very limited because of metal contamination. special applications for ore or ash leaching. Reciprocating ion exchange for acid recovery.	Reducing: metals being recovered in house neutralization to produce a sludge.
(112) Acidic solutions with other metals and non-metals.	Good potential for use as neutralizing soln. Pickle acid can be used for iron salt recovery.	Reducing: in house use for neutralization.
(113) Other acidic solutions.	Good potential for reuse where non pure acid required or for simple alkali waste neutralization.	Reducing.
(12) Alkaline Solution		
(121) Alkaline solutions with heavy metals.	Very limited because of contamination with metals.	Reducing: metals being recovered neutralization to sludge.
(122) Alkaline solutions with other metals and non-metals.	Good potential for use as a neutralizing agent.	Reducing.
(123) Other alkaline solutions.	Good potential for use where non pure materials are required.	Reducing.

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

Inorganics	Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
(13) Metal-Finishing Solutions		
(131) Metal-finishing solutions - acidic.	Metal recovery via ion exchange, membrane process, electrodialysis, acid recovery via ion exchange. (CN^- dealt with under (146)).	Reducing: in house neturalization to sludges, and metals recovery.
(132) Metal-finishing solutions - alkaline.		
(133) Spent pickle liquor.	Good opportunity for iron salt recovery from clean steel pickle liquor; limited use for Zn or Ni contaminated liquors.	Reducing: due to increasing use for recycle.
(14) Other Aqueous (Salt) Solutions		
(141) Other aqueous (salt) solutions with heavy metals.	Very low reuse recycle potential except special instances where very valuable metals or salts are involved.	Some reduction possible by better housekeeping, lower water use or dewatering technology such as membrane processing.
(142) Other aqueous (salt) solutions with other metals.		
(143) Solution containing other reactive anions.		
(145) Brine.		
(146) Solution containing cyanide.		Reducing due to cyanide replacement or new in house reduction technology.
(147) Solution containing sulfide.		

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

Inorganics	Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
(15) Inorganic Solids		
(151) Inorganic solids	Low.	Steady to increasing.
(152) Inorganic chemicals.	Some potential depending on the purity, possible brokerage role for OWMC.	
(16) Other Inorganic Wastes		
(165) Spent catalyst.	Possible regeneration of catalyst by removal of poisons.	Steady or some reduction possible.
(167) Unidentified inorganic wastes.	Low probability of recycle.	Steady to increasing.
Organics		
(21) Spent Solvents		
Halogenated Solvents		
(211) Spent solvents with heavy metals	All prime candidates for reuse in places requiring less than pure solvents. Then recycle through distillation to produce either single component solvents or mixed solvents. Mixtures can be used in degreasing operations, etc.	Decreasing rapidly due to in house recovery, and custom recycling operations. Residue from such operations likely to increase.
(212) Spent solvents with other metals.		
(213) Other halogenated solvents, incl. mixed.		

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

Organics	Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
Non-Halogenated Solvents		
(214) Spent solvents with heavy metals.	As above. Mixed non-halogenated solvents in demand for paint applications. Several small package distillation units available for in house recovery operations.	Decreasing. Still bottoms from recovery operations likely to rapidly increase.
(215) Spent solvents with other metals or non-metals.		
(216) Other non-halogenated solvents, incl. mixed.		
(217) Unspecified solvents.		
(22) Other Oganic Liquids		
(221) Other organic liquids with halogens and metals.	Unclear exactly what these materials might be. Little likelihood of major recycle opportunities except for single component streams, where fractional distillation might be utilized to recover a product.	Steady, some increase possible, although good housekeeping practices may reduce quantities going to waste.
(222) Other organic liquids with halogens.		
(223) Other organic liquids with heavy metal only.		
(224) Other organic liquids.		

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

		Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
Organic Residues			
(225)	Aqueous solution with non-halogenated organic residues < 10%.	Unlikely that economic recovery is possible from these low concentration wastes.	Steady to increasing slightly.
(226)	Aqueous solutions with halogenated organic residues < 10%.		
(227)	Aqueous solution with non-halogenated organic residues > 10%.	Possible recovery using distillation, membrane processes. Solvent extraction, etc., to recover organics from water.	Steady to decreasing slightly if recovery is practised.
(228)	Aqueous solution with halogenated organic residues > 10%.		
(24)	Other Organic Wastes		
(241)	Pesticides and Wastes.	Almost zero.	Steady to increasing.
(242)	Polychlorinated biphenyls (PCBs) and material containing PCBs.	Zero except to destroy PCBs, and recover material such as oils that it is contaminating.	Initial surge, then steady, then decreasing, no future production.
(243)	Pharmaceuticals and wastes.	Low reuse opportunities except for solvents.	Steady, small quantities in Canada.

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

Other Organics Wastes		Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
(244)	Photochemicals and wastes.	All silver now recovered in house. Other chemicals limited opportunity for recycle.	Increasing.
(245)	Off-specification or aged organics.	Possible reuse. Fuel uses if no noxious contaminants.	Steady.
(248)	Still bottoms (distillation residues) without halogens.	Useful as a boiler fuel.	Increasing.
(251)	Liquid tannery wastes.	Opportunities for recovery of chromium through precipitation or incineration. Land disposal of sludges as soil conditioner.	Liquid wastes going to sewage treatment plant.
(252)	Solid or sludge tannery wastes.		Solid waste: steady to decreasing.
(254)	Adhesives or glue.	Opportunities for reuse if product is not spoiled. Prime candidates for waste exchange.	Should be suitable for municipal landfill if no users found.
(26)	Polymeric Material and Wastes		
(261)	Polymeric resin.	All can be reused. If not in critical items can be used for toys, floor tiles, packaging, etc.	Should be zero.

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

		Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
Polymeric Material and Wastes			
(262)	Latex and Wastes.		
(263)	Other polymeric wastes, thermoplastic, or not stated.	High recycle potential provided sufficient quantity can be gathered. Use in non critical items, fence posts, calf pens, etc.	Should go to municipal landfill if not recycled.
(264)	Other polymeric wastes, thermoset.	More limited recycle opportunity. 10 -15% of ground up thermoset can be incorporated as filler in new thermosets.	Should go to municipal landfill if not recycled.
(28)	**Oily Wastes**		
(281)	Waste oil and mixed oil.	Oil rerefining to new product, fuel use in cement kilns. Road oiling for dust suppression.	Should be very low except from oils highly contaminated with PCBs, etc.
(282)	Oily tank bottoms.		
(283)	Oily mud or sediment and water.	All of these categories have some limited opportunities for recycle. Most are oil water emulsified mixtures such must be separated using one of a variety of techniques such as: - air flotation - centrifuging - ultrafiltration - etc. After the oil is concentrated it can possibly be rerefined or used as a fuel. Non metal contaminated oily wastes could be landfarmed.	Steady. Could increase or decrease depending upon the ingenuity of oil rerefiners in Ontario!
(284)	Oily acidic solids.		
(285)	Oily alkaline solids.		
(286)	Oil/Water separator sludge.		
(288)	Oily wastes with heavy metal contaminants.		
(289)	Oily wastes with water.		

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

Sludges (other than those identified above)	Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
(41) Relatively Inert Sludges		
(416) Ink sludge.	Almost no potential except possibly for soil amendment where no toxic materials are involved.	Increasing with deinking plants coming on stream.
(417) Alum and gypsum (mineral) sludges.		
(43) Metal Sludge		
(431) Heavy-metal sludge.	Little immediate potential except in a few cases where metal values are sufficiently high to warrant hydro-metallurgical recovery techniques being applied.	Increasing by-laws with increasingly stringent sewer use laws, greater in plant precipitation of metals being undertaken. Some decrease may be possible as electroplaters turn to electrodialysis or membrane processes for metals recovery rather than precipitating them into sludges.
(443) Sulphur sludge	Possible use for refinery spent caustic within the pulp industry.	Steady to decreasing if reuse is practised.
(444) Cyanide bearing sludge.	None likely unless very high concentrations of valuable metals are contained. In that case leaching to recover metals.	Reducing due to switch away from cyanide, a new development for cyanide destruction.
(445) Plating or metal finishing sludge.		Reducing as plating shops try to recover metal rather than precipitate.

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

		Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
Sludges (other than those identified above)			
(446)	Degreasing sludge.	Recovery of solvents by distillation and reuse of those solvents.	Decreasing due to in-house solvent recovery.
(447)	Tetraethyl lead sludge.		
(454)	Paint sludge.	Pigment and solvent recovery possible. Use of sludges as crude sealants may be feasible. Energy recovery also possible.	Likely to be descreasing due to shift to paints which create less sludge (water based) and the reuse opportunities outlined.
(455)	Paint sludge without heavy metals.		
Miscellaneous			
(509)	Gas cylinders or containers.	After dealing with gas, cylinders could be reused or recycled as scrap.	Small and liable to stay small.
(512)	Spill clean-up.	Unlikely to be significant.	Steady to increasing.
(513)	Laboratory waste chemicals.	Opportunity for OWMC to act as broker? Reuse by schools, etc.	Steady to increasing.
(518)	Dust-collector wastes.	Dependent upon source. Some metal dusts have great recycle potential.	Increasing with more stringent air pollution controls.
(521)	Spent cartridge filters.	Unlikely.	Increasing.

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INITIAL ASSESSMENT OF RECYCLE/REUSE OPPORTUNITIES AND PROBABLE QUANTITY TRENDS FOR DISPOSAL BY UCD WASTE CATEGORIES

Miscellaneous		Recycle/Reuse Opportunities	Probable Quantity Trend for Disposal
(523)	Tank bottom sediments.	Limited: possible fuel use or land farming.	Hopefully decreasing with better housekeeping practices.
(528)	Pathogenic wastes.	None.	Probably increasing.
(529)	Explosive Wastes	None or very limited.	Steady or increasing.
(531)	Contaminated rags.		Steady to increasing as municipal landfills refuse to accept contaminated material.
(532)	Equipment and/or containers contaminated with pesticide	Can possibly be reclaimed by flushing with suitable solvents, if the value is sufficiently high, e.g. flushing PCB contaminated transformers with Trichloro Benzine. Creates liquid disposal problem.	Steady to increasing as municipal landfills refuse to accept contaminated material.